Utilization of thermal refugia by salmonids in a stressed river system: implications for design of water quality and biological monitoring programs.

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Abstract

During the summer (June-September) of 2001, biologists with the U.S. Fish and Wildlife Service, Yurok, Karuk and Hoopa Tribes developed a coordinated comprehensive fish kill and water quality monitoring program. The objective of our monitoring project was to evaluate the response of adult and juvenile fish populations to degraded water quality in the Klamath River. Our hypothesis was that emigrating juvenile salmonid fishes maximize exposure to suitable microhabitat within the river system through behavioral modification and selective utilization of thermal refugia surrounding cooler tributaries.

During the survey period elevated temperatures (>21C) were detected in the mainstem Klamath River. Populations of juvenile salmonids responded positively to cooler tributary temperatures by congregating in large schools at the mouths of these waterbodies.. As temperature levels in selected tributaries converged with mainstem temperatures during late summer and/or lower flows the fish would disperse and/or emigrate. This dispersal coincided with natural emigration timing during late summer and early fall. However, movement of fish may have been accelerated in areas were temperature convergence and/or elevated tributary temperatures existed. This effect was most dramatic and accelerated in areas were stream temperatures converged rapidly.

If we had used traditional fixed station monitoring located in the mainstem river or employed a random sampling design we would have failed to represent the complexity of thermal regimes in the river and their effect on fish distribution. A fixed station continuous monitoring network combined with systematic sampling selection protocol for areas of special interest (tributary mouths), would yield more informative data when evaluating river water quality and it's effect on fish distribution. Advanced technologies including forward looking infrared (FLIR) thermal sensors would also be useful for mapping broader scale patterns in thermal regimes and targeting future biological and water quality monitoring.

Introduction

The Klamath River is located in southern Oregon and northern California (Fig 1). The river originates in southern Oregon and travels through approximately 260 miles through mountainous terrain until it reaches the Pacific Ocean. Upper Klamath Lake serves as the starting point for the Klamath River. Several dams and reservoirs are located at the upper end of the system and impound water for irrigation and hydroelectric use. Anadromous fish including chinook and coho salmon and steelhead trout are confined to the lower Klamath River due to blockage of upstream migration by Iron Gate reservoir.

The Klamath River was once the third largest salmon-producing watershed on the west coast, supporting large anadromous fish runs including chinook salmon, coho salmon, steelhead, sturgeon, and lamprey. Today, fish numbers have plummeted. This decline is the result of a variety of factors, including dams, agricultural development, logging practices, mining, and historical overharvest. These factors have contributed to the loss of upstream habitat, impaired water quality, and modified river flows. In addition to these changes brought about by humans, fluctuating natural ocean conditions have influenced fish stocks.

The Klamath River has been modified by a series of six dams that were constructed between 1909 and 1962. These dams, developed primarily for hydropower, stretch over 60 miles of River. The Klamath River Hydroelectric Project has facilities that have been in place and have not changed operations since the early 1900's. Construction of the project's Copco I dam has completely blocked the migration of salmon and steelhead into the upper Klamath Basin since 1917. The hydro-project currently prevents chinook salmon and steelhead from accessing nearly 200 miles of potential habitat upriver of Iron Gate, the lowest project dam. Under the Federal Power Act, the hydroelectric facilities on the Klamath River are scheduled for relicensing by 2006.

Water quality has been, and continues to be, a primary concern in the restoration of anadromous fish species in the Klamath River and it's major tributaries. High nutrient loads, high temperatures and low dissolved oxygen of water leaving Iron Gate Reservoir and the Shasta River need to be addressed to protect the rearing and outmigrating juvenile salmon. During the summer months, fish kills are not uncommon in the river due to poor water quality and quantity. As a result of irrigation and hydroelectric usage the flow regime and water quality of the river has been impacted. In general flows are lower than historical levels and nutrient levels have been elevated due to increased agricultural runoff (McClurg 2000). In addition, water temperatures in the lower Klamath River are often elevated above water quality criteria (North Coast Regional Water Quality Board 2000).

Despite the serious decline in salmon numbers on the Klamath, there is great potential for recovering a large section of the Klamath Basin. Nearly 200 miles of the lower Klamath remains free-flowing and is accessible to salmon -- the River has been placed under the California and National Wild and Scenic River Systems to recognize and protect the River's outstanding anadromous fishery values.

The U.S. Fish and Wildlife Service initiated in 2001, along with it's cooperators, has initiated an instream flow analysis focused at restoration of not only the Klamath River, but it's major tributaries. The Klamath River Flow Study Technical Advisory Group (TAG) includes scientists, biologists and other technical representatives of various state and federal resource agencies, EPA, North Coast Regional Water Quality Control Board, the USBR, U.S. Forest Service, local watershed groups, Klamath Water User's Association, and PacifiCorp. This study will build upon existing information, and will examine the relationships among fish habitat, instream flow, and water quality. In addition, the study will focus on the development of sound engineering solutions with recommendations for future on-the-ground restoration activities. These recommendations will be a result of a coordinated effort between agencies and local stakeholders.